

# Mutual Ground

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# Intersubjectivity

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- What we “mentally share” about the world
  - Sense of reality
  - Meaning
  - Framework for coordinated activity
  - Includes cultural basis for behavior
- Size of interactive space can vary



# Three Elements

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- Biology
  - Visual apparatus
- Representation
  - Internal (prior knowledge)
  - External (artifacts that mediate)
- Interaction
  - organization of exchanges



# Dynamics

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- Idiosyncratic and historical character
    - the physical environment
    - the actors
    - the prior experiences of the actors are different
  - Design of task environments also changing.
  - Account for
    - the difference between,
    - the change among,
    - the “sameness” of,
- Similar types of encounters



# Model

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- The Equivalence of Internal Representations
- Interaction and Common Ground
- Mutual Ground
- Accumulation
  - Conversational Structure
  - Coordinating Representations
  - Cycle
- Cognition



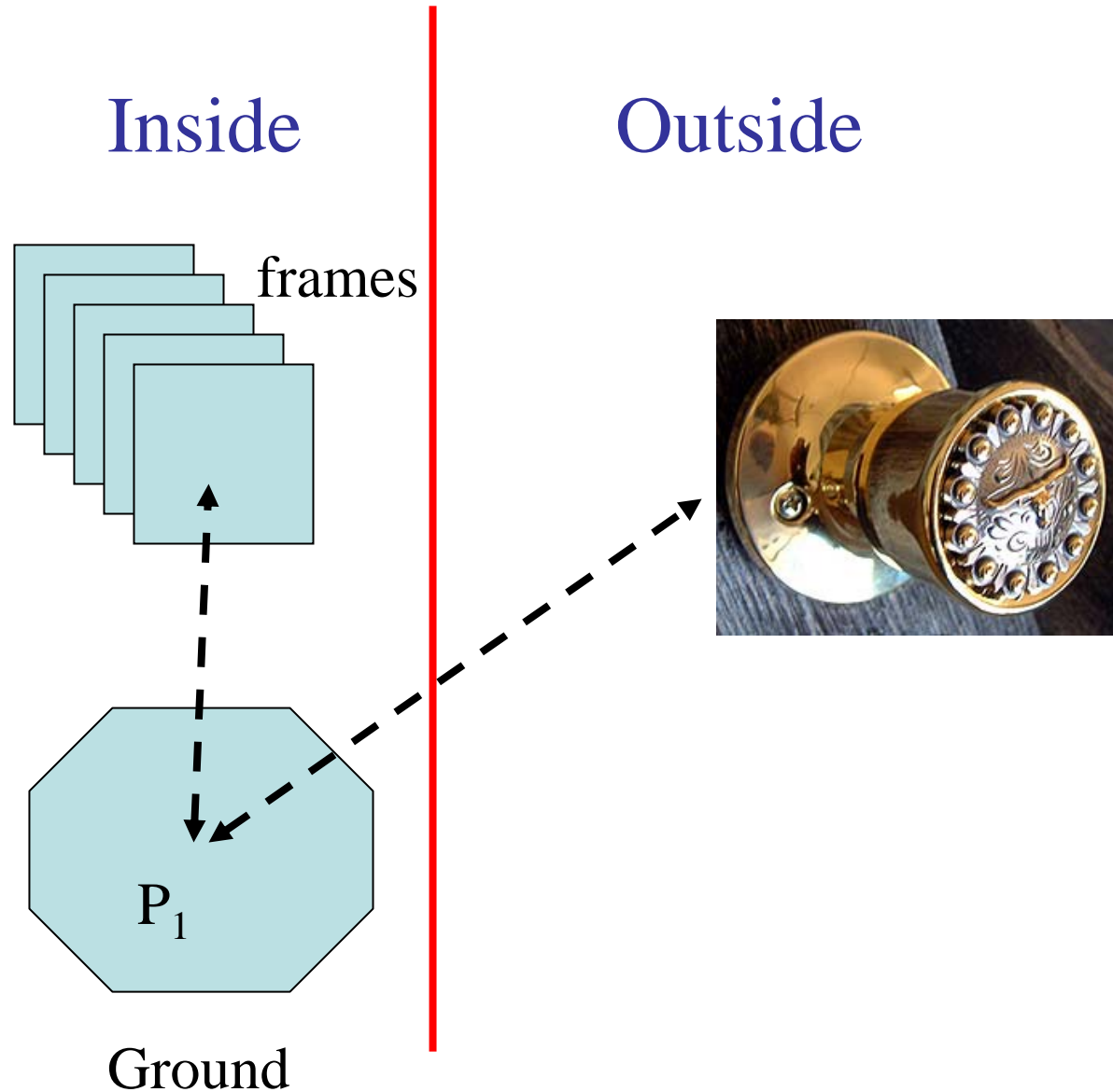
# Equivalence of Mental Representations

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- Does a shared intersubjective space mean identical/intersecting mental representations of the situation at hand?

# Opening a Door

- The doorknob (external object)
- The frame the predicts the doorknob (knowledge)
- The grounding of the doorknob slot

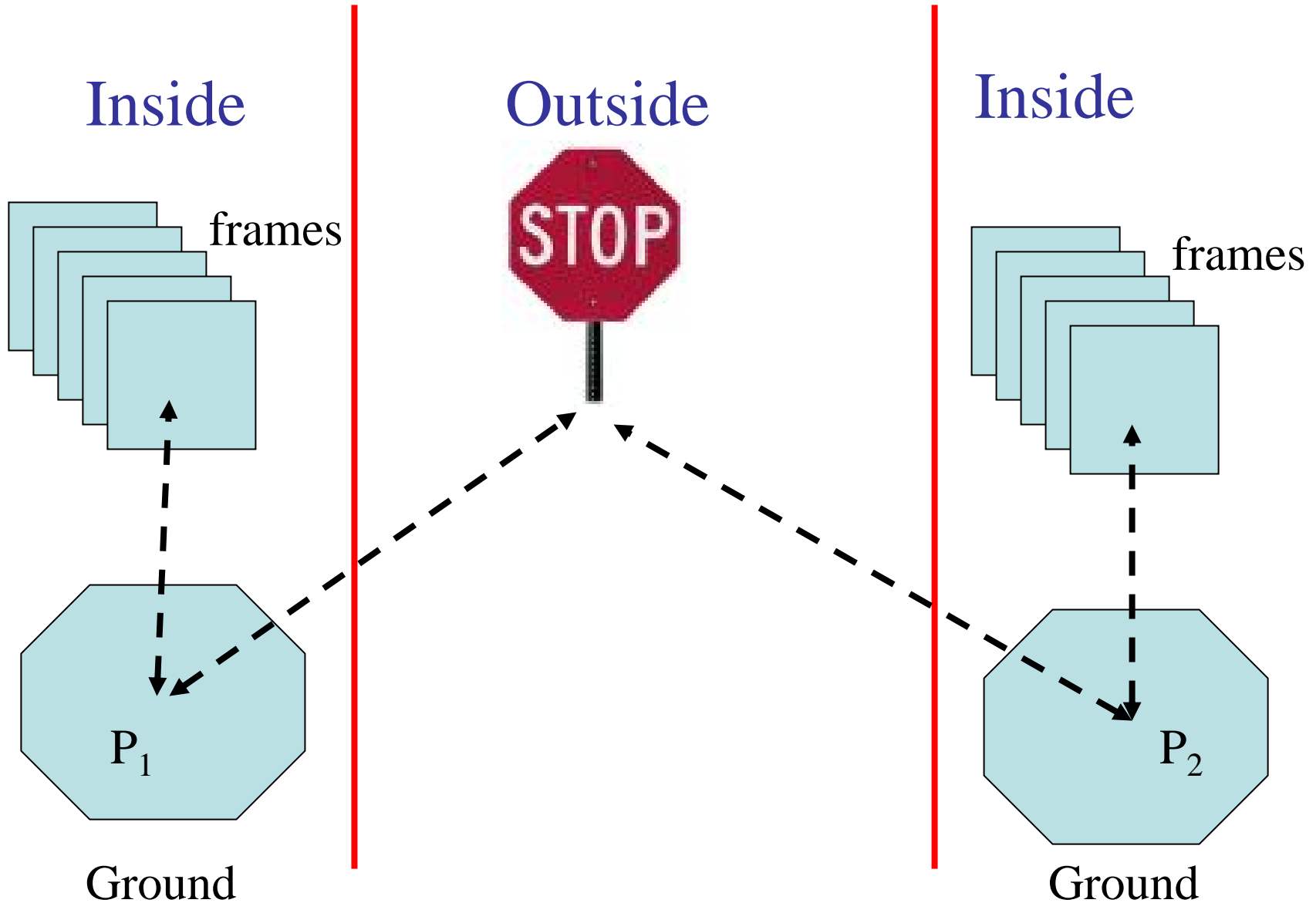


# The Stop Sign

- Individual knowledge of stop signs
  - Rules of about stopping (DMV)
  - Meta knowledge about conventions for acting when stop signs are at the scene of the activity
- Knowledge about the types of participants and expectations of how they might act
- Road conditions, how heavy traffic is, time constraints
- Only a selection of this knowledge is grounded by each individual



# What is shared?





# Representations are functionally equivalent

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- Does a shared intersubjective space mean identical/ intersecting mental representations of the situation at hand?
  - No
- From the point of view of an outside observer, one could claim that their ground functioned as if both actors ground the predicate that one of them would go first



# Interaction not representation

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- Instead, what seemed programmatically promising was a *procedural* sense of “common” or “shared,” a set of practices by which actions and stances could be composed in a fashion which displayed grounding in, and orientation to, “knowledge held in common” – knowledge that might thereby be reconfirmed, modified, expanded and so on. (Schegloff, 1993: p. 1298)



# Conversational Analysis

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- Organization of the interaction
  - Display understanding of situation-at-hand
  - Recognize and repair breakdowns in intersubjectivity
- Conversation
  - Sequential
  - Interactants take turns
    - First position: speaker presents contribution
    - Second position: other participants have opportunity to display response
    - Third position: initial speaker can amend her presentation if it did not invoke a preferred response



# Clark's Common Ground Criteria

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- For two people A and B,  
it is common ground that  $p$  iff;
  - A and B have information that some basis  $b$  holds;
  - $b$  indicates to A and B that A and B have information that  $b$  holds;
  - $b$  indicates to A and B that  $p$ .



# Has problem of equivalence of representations disappeared?

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- Does not seem necessary that A and B have grounded the exact same  $P$ 
  - A believes  $P_1$
  - B believes  $P_2$
  - $P_1$  and  $P_2$  are at best some epsilon away from each other
- Ditto for the basis  $b$

Functioning of mental representations



# Mutual Ground

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A and B are acting.

- If A's behavior is mediated by some internal frame  $F_i$ .
  - Normally achieves his goal
  - Consistent/grounded with action of B up to that point
- Then A believes that he can use  $F_i$  to continue the interaction.

If B's actions do not fit into the frame that mediates A's behavior

- either a new frame is selected by A to internally mediate his behavior,
- or a meta-process to align private representations of shared activities is invoked.



# Breakdown

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- A and B have internal frames that are not aligned and a breakdown occurs, i.e.,
  - Either
    - A's internal mediator  $F_i$  cannot ground B's behavior in the frame that achieves A's goal and explains B's behavior.
  - Or
    - B's internal mediator  $F_j$  cannot ground A's behavior in the frame that achieves B's goal and explains B's behavior.



# Breakdown & Meta-Interaction

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- A breakdown occurs and there is a communicative interaction
  - This is a *meta-interaction*.
- Since A and B can never directly compare their internal representations of the situation, this meta-interaction is essentially a pointing game.
  - One actor makes a presentation and the other actor either accepts the presentation or indicates that further clarification is needed.



# Mutual Grounding

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- A makes a presentation
  - Presentation points to what A believes is a commonly known organization of behavior that achieves A's goal and that A believes B will agree to participate in.
- B accepts A's frame if
  - B can find an internal mediator  $F_j$  that achieves B's goal and grounds A's behavior.
- Mutual Ground Criteria
  1. A's presentation is grounded by A to indicate frame  $F_i$  and by B to indicate  $F_j$
  2. A believes  $F_i$  will lead to the achievement of A's goal and it accounts for B's behavior
  3. B believes  $F_j$  will lead to the achievement of B's goal and it accounts for A's behavior



# Common Ground Versus Mutual Ground

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- Every case of mutual ground is a case of common ground but not vice versa
- Deception can be explained in terms of mutual ground
- Difference in recall of prior events can be explained by mutual ground not common ground
- Expert and novice interaction
- The mental sharing of collaborating actors with different roles
- When one participant is bored or not interested in arguing, progress in the interaction



# Model

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- The Equivalence of Internal Representations
- Interaction and Common Ground
- Mutual Ground
- Accumulation
  - Conversational Structure
  - Coordinating Representations
  - Cycle
- Cognition



# Accumulation

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- Reduction in the amount of collaborative work in recurrent activities
- Debugging
- Functional distance between individual representations of the recurrent activity decreases.
- Mediate the interaction
  - conversational structure that organizes the meta-interactions within the team.
  - pre-design the team's task environment



# Recurrent activities produce conversational structure

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- Invention of conversational structure
  - First form of social accumulation
  - Flexible

## Telephone Conversation (Core Opening Sequence)

1. The summons/answer sequence
2. The identification (and/or recognition) sequence
3. Greetings
  - Ratified mutual participation
4. 'Howareyou'

(Schegloff 1986)



# Mutual Ground and Conversational Structure

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- Suppose Simone wants to call her lover Jean Paul on the phone to let him know her flight has been cancelled:
  - $F_i$   
Her plan to inform Jean Paul that her flight is canceled
  - $C\_O\_S_i$   
Her internal representation of the core opening sequence



# Re-design the Task Environment

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- Invention of conversation structure is not always ideal
- Embed in task environment some preferences for organizing recurrent behaviors
  - Pre-computes some of runtime work of actors (Norman, 1991)
  - Enables distribution of work



# Coordinating Representation

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External representation available at the scene of the activity prior to the current activity that was designed to “solve” a problem in aligning private view of shared activity

- Stop sign
- Clock
- Appointment slip
- Airport
- Mail order catalogue
- Words/Signs



# Coordinating Representation

(continued)

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- All artifacts can be used to mediate the co-construction of a shared understanding, but not all artifacts are designed to do that
- Not all external representations are intended to mediate an interaction between actors
  - Personal diary
  - Scratch sheet that is used to do arithmetic calculations
  - Earlier drafts of this talk



# Mutual Ground and Coordinating Representations

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- Suppose A performs an action/presentation/display  $p$  during an interval of cooperation with B who has goal  $G$ 
    - B's behavior is mediated by coordinating representation  $C$  that B has grounded using  $F_j$
  - B will invoke a meta-interaction if
    - B cannot ground  $p$  in a manner consistent with  $F_j$
- Or
- B cannot find an alternate frame  $F_k$  that grounds  $G$ ,  $C$ ,  $p$ , and the prior actions of A during the current interval of action



# Cycle

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- As a group begins to collaborate, they settle into a routine
  - They make choices about how to represent and reason about various aspects of the task
- Design of task environment is never a fixed point
  - Recurrent breakdowns
  - Better ideas, new technologies, attitudes, trends, styles
- Changes to task environment (new CR's) ⇒  
Changes to interaction ⇒  
New conversational structures



# The vocabulary of the interaction

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- The coordinating representation  $C$  is part of the vocabulary used for communicating, thinking and assessing
  - The departure/arrival monitor at the airport mediates the “pointing” between airport personnel and passengers
  - Without the departure/arrival monitor the sense the actors make of the situation, the way in which they reason about the situation, the structure of their activity is entirely different
- Continued use of  $C$  changes how the actors jointly construe their engagement
- Vygotsky
  - All higher level functioning begins with the social



# Computational Methods

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- Collecting data from online collaborations
- Cognitive Engineering
- Cognitive Modeling

# Collect Data

**World**

toggle zones toggle labels toggle chart

Sun Dec 17 21:39:18 EST 2000

**IncomingCommunicationView**

```

crane2: I am at 332,213
tug1: Net medium !!leaking 407 376
tug1: I'm at 408 332
crane2: I have 3 M? !!@269,247|m? !! 296,305|m? !! 373,301
crane1: ill head east along the bottom
crane2: I'll go west then north
: ---- starting round 2 -----

tug1: Currently moving to barge.
crane2: ohh was my compression of the waste info understandable
crane1: yeah
: ---- starting round 3 -----

crane2: M? !!@546,295
crane1: large !! 389 81
: ---- starting round 4 -----
    
```

Sun Dec 17 21:39:18 EST 2000

**PlanningListView**

crane1	crane2	tug1
Move to (195 93)	Move to (515 404)	Push small barge to (...)
	Move to (519 307)	Move to (375 423)
	Move to (521 404)	Move to (370 435)
		Push small barge to (...)

Sun Dec 17 21:39:18 EST 2000

**VCRControl**

Current time 977107725096 Sun Dec 17 21:48:45 EST 2000  
 Current round 5 152

start |< step < stop || step > play -> ff >>

Go to bookmark 977107230679: This is a... Add bookmark ...

Go Next Round

Session Sun Dec 17 21:39:18 EST 2000  
 Time /home/afeinman/Research/ExperimentData/977107158884/log.xml  
 Status VCC\_STEP\_FORWARD  
 Event Unknown Event  
 Time Elapsed 2397ms since last event.

Open Chooser Open Annotations Open Window View

Quit

Sun Dec 17 21:39:18 EST 2000

**Marker List**

```

(375, 300) m dredge by crane1
(400, 375) m net by crane1
(250, ...
(250, ...
(550, ...
(375, ...
(275, ...
(275, ...
(500, ...
    
```

**Annotations**

```

- clarification of new convention
977107501337 - comm of cg1
(375, ...
977107725096 - med 4 reference is wrong
(275, ...
(500, ...
    
```

med 4 reference is wrong

save goto next discard

Sun Dec 17 21:39:18 EST 2000

# Workforce Application

**WORKFORCE SCHEDULE WORKSHEET**  
**SCENARIO 1**

Hour	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
8 – 10 am	I	I	I			E	
10 – 12 am	I	I	I				
12 – 2 pm		F			F		
2 – 4 pm						E	
4 – 6 pm							
6 – 8 pm						E	
Employees required	3	3	5	4	6	7	4

AI  
Bob  
CeCe  
Dan  
Ed  
**Fay**  
Gail  
Hal  
Ian  
Jen

OVAL SELECT DELETE

CREATE  
NOTIFICATION: other has joined.  
other: hi  
other: why don't you work on these days  
seth: ok

Send

Elapsed time: 0:01:12

Quit PANIC

**WORKFORCE SCHEDULE WORKSHEET**  
**SCENARIO 1**

Hour	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
8 – 10 am							
10 – 12 am							
12 – 2 pm							
2 – 4 pm							
4 – 6 pm							
6 – 8 pm							
Employees required	3	3	5	4			

AI  
Bob  
CeCe  
Dan  
Ed  
Fay  
Gail  
Hal  
Ian  
Jen

OVAL SELECT DELETE

NOTIFICATION: seth has joined.  
seth: hi there  
other: hi  
seth: you do this area  
seth: are you paying attention?

Send

Elapsed time: 0:01:35

Quit seth  
PANIC: 1072205701287

timestamp 1072205704437 position 10 / 13  
Last Event: t4g.carb.SharedButtonActionCarb  
Event type: No Event Filter



# Cognitive Engineering

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- Online practice is grounded in a representational system
- Transcripts are collected
- Identify weak spots
  - Coordination work & cognitive load
- Re-design task environment
  - Introduce new coordinating representations.
  - Leverage coordinating representations to add adaptive components.

# GrewpTool

The screenshot displays the GREWP 2.0 web interface, version 5/1/2003. The interface includes a menu bar with 'File', 'View', and 'Options'. Below the menu is a tabbed interface with three tabs: 'network', 'Bnon==test.scm', and 'Anon==person.scm'. The 'Anon==person.scm' tab is active, showing a chat log with the following messages:

- Bnon: Remember that we are just given the ankle!
- Anon: OK. So I'll try to draw the foot underneath there...
- Bnon: Good job. I'll fix the length of the foot, you work on the other foot.

Below the chat log is a code editor with the following code:

```
(define c (canvas 500 500))

(define (part1 g)
  (.setColor g pink)
  (.fillRect g 190 460 30 20)
  (.fillRect g 160 480 60 20)
  (.setColor g pink)
  (.fillRect g 190 460 30 20)
  ;; write your code here for part 1
)

(define (part2 g) '0)
;; write your code here for part 2
)

(define (part3 g) '0)
;; write your code here for part 3
)

(define (part4 g) '0)
;; write your code here for part 4
)
```

On the left side, there is a 'Private Browser' window with the following text:

If you have finished part I, you may [click here to go to part II.](#)

Otherwise click [here](#) to continue working on part I.

The address bar shows: `msets/scheme/graphics_man/ps01a.html`

On the right side, there is a 'Public Browser' window with the following text:

## Help Pages for the "Graphics: Man Problem Set"

### Graphics Procedures

The Graphics class contains several methods for drawing onto a canvas. Before you can use them you need to understand the coordinate system used by these methods.

### Coordinates

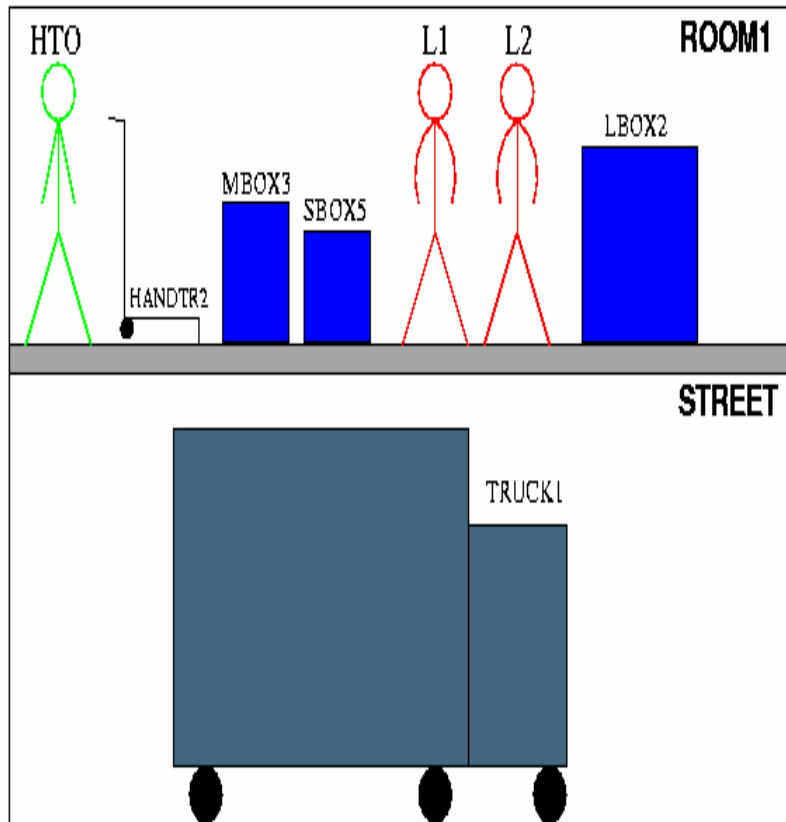
The address bar shows: `090/aut02/GREWP/problemsets/scheme`

At the bottom of the interface, there is a status bar with the following text:

Mon Nov 24 12:04:58 EST 2003 (GREWP)--L4--C13--Total--L64--C21

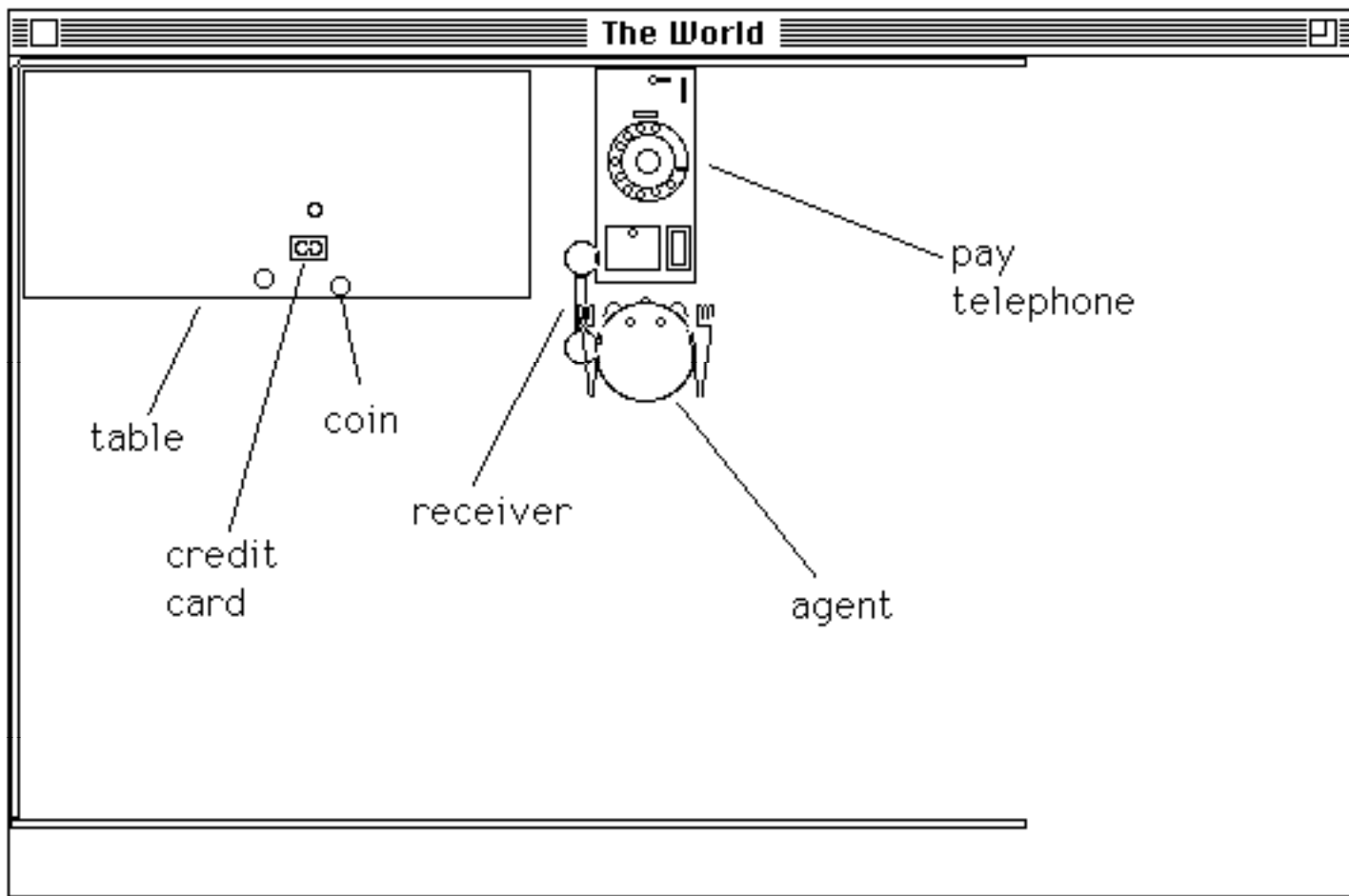
Below the status bar are several buttons: 'PANIC', 'edit mode', 'eval', 'highlight', and 'clear highlight'.

# Cognitive Modeling



■ Convention

# Cognitive Modeling



- Skill Acquisition
- Adaptive Planning
- Instruction Usage



# Talk Summary

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- Model
  - The Equivalence of Internal Representations
  - Interaction and Common Ground
  - Mutual Ground
  - Accumulation
    - Conversational Structure
    - Coordinating Representations
    - Cycle
  - Cognition